ORIGINAL RESEARCH

Voiding Pattern of Toilet-Trained Filipino Children With Recurrent Urinary Tract Infection and Without Urinary Tract Infection

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Objectives: The objectives of this study were to compare the voiding pattern of toilet-trained patients with and without recurrent UTI, to describe the voiding pattern of toilet-trained patients without UTI aged 2 to 15 years old and to describe the voiding pattern of toilet trained patients with recurrent UTI aged 2 to 15 years old.

Materials and Methods: A total of 80 toilet-trained Filipino children divided into two groups with 40 each were included. R-UTI group consisted of patients aged 2 to 15 years old who presented with recurrent UTI. The control (No-UTI) group consisted of children aged 2 to 15 years old without any urinary symptoms and without history of urinary tract infection. Parents completed a 72-hour bladder chart at home. All participants answered Farhat's DVSS. Patients underwent uroflowmetry, uroflowmetry with EMG and post void residual assessment (PVR). Qmax, uroflowmetry pattern, bladder wall thickness and PVR were recorded and analyzed using independent t-test.

Results: The mean age of subjects with UTI was 6.32 ± 2.77 years and those in the control group have a mean age 6.67 ± 2.77 years old. Of patients of R-UTI group the following were statistically significant compared to No-UTI : Constipation (48% vs 15%), mean frequency of voiding volumes greater than 125% of the estimated bladder capacity (EBC) at daytime (0.8 ± 0.22 vs 0.05 ± 1.20 p=0.0002), frequency (45% vs 5%), mean average voided volume (126.54 ± 56.05 mL vs 84.34 ± 34.26 mL p=0.0001), mean daytime average voided volume (121.33 ± 59.59 mL vs 87.90 ± 36.41 mL p =0.0033), mean maximum voided volume (232.25 ± 113.99 mL vs 130.85 ± 49.99 mL p<0.0001), mean bladder thickness (3.83 ± 0.68 mm vs 3.38 ± 0.62 mm p = 0.0030), mean PVR (12.96 ± 10.54 mL vs 5.21 ± 5.68 mL p=0.0001). PVR was significant in 45% of cases compared to 3% significant PVR (when 4-6 years old defined as >10ml or >10%of EBC, and if >7 years old >20ml or >15% of EBC). When mean PVR was computed as percentage of EBC, R-UTI group had a statistically higher percentage compared to the no-UTI group (6.27 ± 2.52 % vs 2.52 ± 2.75 % p=0.0001). Mean observed bladder capacity (OBC) was found to be more than the EBC in 35% of cases in the R-UTI group compared to 12% of No-UTI group (p=0.018). Uroflow-EMG in the R-UTI group were, 85% synergic, 12% dyssynergic and 3% interrupted pattern. EMG in the No-UTI group were, 38% synergic, 55% dyssynergic, 2% delayed relaxation, 5% interrupted. The EMG patterns were statistically significant between the groups (p<0.0001). Uroflow patterns were comparable between the two groups (p=1.000).

Conclusion: Constipation was more frequent in the R-UTI group. R-UTI group had a higher mean frequency of EBC > 125% during daytime, frequency, mean average voided volume, mean average voided volume during daytime, mean maximum voided volume, mean bladder thickness, mean PVR compared to the without UTI group. Mean observed bladder capacity was observed to be greater than the EBC in the R-UTI group compared to the No-UTI group. R-UTI group was synergic compared to No-UTI group which were dyssynergic.

Key words: Recurrent urinary tract infection, dysfunctional voiding symptoms score (DVSS)

Introduction

Urinary tract infection (UTI) is defined as the presence of bacteria in the urine along with symptoms of infection. It is one of the most common bacterial infections in children. The reported prevalence in toilet-trained children is 1.7% in boys and 8.4% in girls.[1] Vesicoureteral reflux (VUR), bladder-bowel dysfunction (BBD), female sex, constipation, lack of toilet training and inadequate water intake are significant risk factors for febrile UTI and recurrent UTI in children.[2,3]

Incomplete bladder emptying has been thought to be related to bladder sphincter dyssynergia. Bladder sonography is routinely used to assess the bladder wall thickness, post-void residual urine (PVR) and bladder volume as an initial evaluation of many children with voiding dysfunction.[4]

Uroflowmetry and post-void residual urine have gained wide acceptance as initial screening tests for evaluation of voiding function in children because it's non-invasive and relatively inexpensive.[4] The results of uroflowmetry tests show the general bladder contractility and bladder outlet resistance. Abnormal uroflowmetry parameters were seen in 76% of patients with recurrent UTI.[5] Among these parameters, Qmax was the most relevant parameter for interpretation thus several nomograms for Qmax in children were established.[4,6] Adding simultaneous EMG allows observation of pelvic floor electrical activity (a surrogate for external urethra sphincter) during voiding.[7]

Uroflow pattern was also an important parameter in uroflowmetry. The International Children's Continence Society (ICCS) has classified uroflow patterns into bell-shaped, staccato, plateau, interrupted and tower-shaped curves.[4] However, there were conflicting data in its use in predicting UTI. There was no correlation between uroflow or electromyography results and volume of residual urine on ultrasound.[8] Although staccato uroflow pattern was found to be the most common uroflow pattern in patients with dysfunctional voiding.[9]

Materials and Methods

The study employed a cross-sectional study design. A case (R-UTI) was defined as a toilet-trained patient aged between 2 to 15 years old presenting at a pediatric urology clinic with recurrent UTI (no breakthrough UTI). A control (No-UTI) on the other hand was defined as a patient presenting in a general pediatric clinic without urinary symptoms and without history of urinary tract infection. A total of 80 patients were asked to participate in the study with a 1:1 ratio of cases and controls. Cases were recruited from a single surgeon, pediatric urology clinic, while controls were recruited from a community.

Patients with obvious neuropathic bladder such as spinal meningomyelocele, Pott's spine poliomyelitis primary nocturnal enuresis; post vesical obstruction such as posterior urethral valve (PUV), meatal stenosis, congenital anatomic abnormality of the bladder; diabetes mellitus; proteinuria and patients who underwent previous surgery of the bladder were excluded from the study.

Study took place in a private pediatric urology clinic. Informative and interactive sessions for parents and guardians were organized to explain the test, its safety and purpose. No-UTI subjects were recruited from the community. Written informed consent was obtained from parents of children who participated in the test. Urodynamic studies were performed using Delphis (Laborie Medical Technology) and included a cystometrogram, patch electromyogram, recordings and uroflow.

History and relevant clinical examination results were recorded. Information was gathered via questionnaire regarding age of the child, sex, age of toilet training, presence of day or night incontinence, urgency, parent-reported constipation and encoporesis.

Parents and participants completed a 3-day bladder chart. The patients were subdivided into 2 groups: Case group (R-UTI) consisting of patients with recurrent UTI and control group (No-UTI) for participants without UTI.

After completion of 3-day bladder chart at home, patients were assigned a schedule of visit to the study site for completion of the tests. Accompanied by their parents or guardians, the patients underwent a dipstick test to confirm the absence of UTI.

A participant from either control or case group who tested positive for UTI on dipstick, was withdrawn from the study and given request to undergo microscopic urinalysis and referred to a pediatrician for treatment. Patient was free to withdraw at any point of the study without penalty or loss of entitlements.

Parents and children answered Farhat's DVSS (A Filipino version of Farhat's DVSS was validated by Lim, Bolong, et al. last 2015). The cutoff were six points for girls and nine points for boys. Patients were allowed to go to the toilet each time they felt the urge to void. A trained urological nurse helped each child finish the test with the principle, "No rush, no push". The boys voided while standing and girls voided while sitting with adequate foot support. They underwent uroflow EMG. All post-void residuals (PVRs) were assessed by the same study nurse within 5 minutes, usually immediately after voiding suprapubic ultrasound. Estimated volumes were computed using the equation height x width x depth x 0.52 mL only when voided volume was greater than 50 mL.

Uroflow EMG was performed by the same trained urological nurse. The patients were encouraged to drink fluids. Pediatric adhesive electrode pads were placed immediately adjacent to the anus at the 3 and 9 o'clock positions. Baseline EMG was be completed by the child in a right lateral recumbent position. After a baseline reading, the subject was transferred to the uroflowmetry toilet seat and was instructed to remain still without voiding until the EMG wave form was stabilized. A footstool was provided for small children as legs support. The flow curve shape was recorded. Flow urine measurement in a child was repeated again at the same setting in a well-hydrated child to ensure that a reasonable volume of urine is expelled with each micturition. Uroflowmetry flow patterns were classified as bell-shaped, plateau or fractionated.

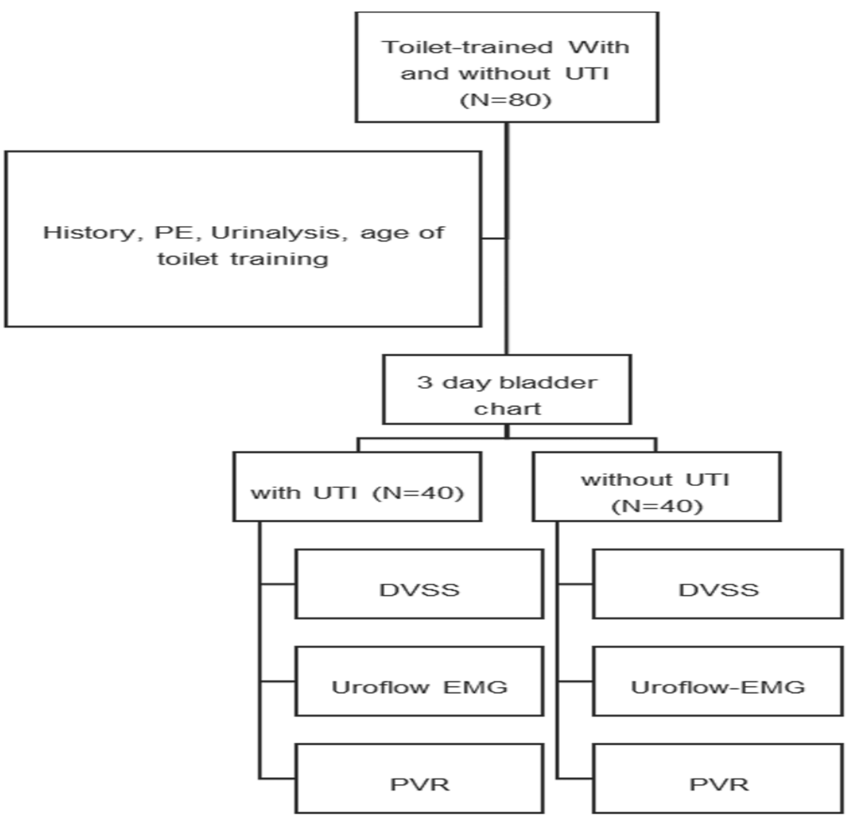

Figure 1. Algorithm of methodology of patients

Toilet-trained participants were expected to undergo a total of at least 4 urinations. Two urinations were done with uroflowmetry and the last 2 urinations were done with uroflowmetry + EMG.

Statistics

STATA/SE ver 12 was used for both descriptive and inferential statistics. Charts and graphs for the presentation of results were generated using Microsoft Excel 2007.

Data were subjected to chi-square test, Independent-t test and Fisher exact test.

Results

A total of 80 toilet-trained patients were included in the study with 40 patients in each group. The mean age was 6.32 ± 2.77 years old in R-UTI group and 6.67 ± 2.27 in the No-UTI group. There were 7 patients and 6 patients less than 4 years old in the R-UTI group and No-UTI group respectively. There were 33 patients ≥ 4 years old in the R-UTI group and 34 in the No-UTI group. There were 31 female patients and 9 male patients in each group. There were significantly more constipated patients (47%) with R-UTI compared to 15% No-UTI (p=0.002). DVSS scores for both groups were comparable (4.13 ± 3.57 vs 3.58 ± 3.28, p=0.4751) (Table 1).

In the R-UTI patients, 4 (10%) were diagnosed normal urologically, 13 (32%) had BBD, 1 (2.5%) had DV, 1 (2.5%) had volume postpone, 15 (37.5%) had high PVR and 2 (5%) had other conditions (Table 2).

Table 2. Diagnosis of patients with R-UTI

Diagnosis[d]	n=40 (N%)
Normal	4 (10)
BBD	13 (32)
DV	1 (2.5)
Volume postpone	1 (2.5)
High post-void residual	15 (37.5)
Others	2 (5)

Patients in the R-UTI group have a significantly higher mean frequency of EBC > 125% during daytime (0.80 ± 0.22 vs 0.05 ± 1.20, p=0.0002). R-UTI group had a significantly higher abnormal frequency of voiding compared to the No-UTI group, with normal frequency (43% vs 90%), infrequency (12% vs 5%) and frequency (45% vs 5%). Mean average voided volume was also significantly higher in the R-UTI group (126.54 ± 56.05 mL vs 84.34 ± 34.26 mL,

Table 1. Patients demographics

Characteristics	Toilet Trained		
	R-UTI (n=40) N%	No-UTI (n= 40) N%	p Value
Age (in years), mean	6.32 ± 2.77	6.67 ± 2.77	0.5742
Age categories			
2 - <3 years old	3 (7)	1 (2)	0.800
3 - <4 years old	4 (10)	5 (13)	
≥4 years old	33 (83)	34 (85)	
Sex			
Female	31 (50)	31 (50)	
Male	9 (50)	9 (50)	1.000
Constipation[a]			
With	19 (48)	6 (15)	0.002*
Without	21 (53)	34 (58)	
DVSS (for toilet trained), mean[c]	4.13 ± 3.57	3.58 ± 3.28	0.4751

[a]Chi square test was used

p=0.0001). Mean average voided volume during daytime was also significantly higher in the R-UTI group (121.33 ± 59.59 mL vs 87.90 ± 36.41 mL, p = 0.0033). Mean maximum voided volume was significantly higher in the R-UTI group as well (232.25 ± 113.99 vs 130.85 ± 49.99 mL, p<0.001) (Table 3).

Mean bladder thickness was significantly higher in the R-UTI group compared to the No-UTI group (3.38 ± 0.68 mm vs 3.38 ± 0.62 mm, p=0.0030). Mean PVR was also statistically significant in the R-UTI group compared to the No-UTI group (12.96 ± 10.53 mL vs 5.21 ± 5.68 mL, p = 0.0001) and 45% of which were clinically significant. Mean PVR as percentage of estimated bladder capacity was significantly higher in the R-UTI group at 6.27 ± 4.94% vs 2.52 ± 2.75% (p = 0.0001). Thirty-five percent of the OBC was more than normal in the R-UTI group compared to 12% in the No-UTI group (Table 4).

Qmax was comparable between the two groups (19.09 ± 6.98 mL/sec R-UTI vs 16.55 ± 6.70 mL/sec, p=0.1008). Eighty-five percent (85%) of R-UTI patients were synergic, 12% were dyssynergic and 3% were interrupted in the R-UTI group. Thirty-eight percent (38%) were synergic, 55% were dyssynergic, 2% delayed relaxation and 5% interrupted in the No-UTI group. Uroflow pattern was comparable between the two groups with predominantly bell-shaped curves followed by staccato curve (Table 5).

Table 3. 72-hour bladder chart comparison of recurrent UTI and without UTI

Characteristics	Toilet Trained		
	R-UTI (n=40) N%	No-UTI (n= 40) N%	p Value
Frequency of EBC >125% during daytime, mean[c]	0.80 ± 0.22	0.05 ± 1.20	0.0002*
Frequency of voiding (for toilet trained)[a]			
Normal	17 (43)	36 (90)	<0.0001*
Infrequent (<3)	5 (12)	2 (5)	
Frequent (>8)	18 (45)	2 (5)	
Average voided volume, mean[c]	126.54 ± 56.05	84.34 ± 34.26	0.0001*
Average voided volume during daytime, mean[c]	121.33 ± 59.59	87.90 ± 36.41	0.0033*
Maximum voided volume, mean[c]	232.25 ± 113.99	130.85 ± 49.99	<0.00001*

[a]Chi square test was used; [c]independent t-test was used

Table 4. Bladder Profile of R-UTI and No-UTI

Characteristics	Toilet Trained		
	R-UTI (n=40) N%	No-UTI (n= 40) N%	p Value
Bladder thickness, mean[c]	3.83 ± 0.68	3.38 ± 0.62	0.0030*
Bladder capacity, mean[c]	228.86 ± 110.11	193.97 ± 84.39	0.1157
PVR, mean[c]	12.96 ± 10.54	5.21 ± 5.68	0.0001*
PVR interpretation[a]			
Significant	18 (45)	1 (3)	<0.0001*
Not significant	22 (55)	39 (97)	
PVR % EBC, mean[c]	6.27 ± 4.94	2.52 ± 2.75	0.0001*
EBC vs. OBC			
Within normal	26 (65)	35 (88)	0.018*

[c]independent t-test was used

Table 5. Uroflowmetry + EMG parameters of R-UTI and No-UTI

Characteristics	Toilet Trained R-UTI (n=40) N%	No-UTI (n= 40) N%	P Value
Qmax (for toilet trained)[c]	19.09 ± 6.98	16.55 ± 6.70	0.1008
EMG Pattern[b]			
Synergic	34 (85)	15 (38)	<0.0001*
Dyssynergic	5 (12)	22 (55)	
Delayed relaxation	0	1 (2)	
Interrupted	1 (3)	2 (5)	
Uroflow Pattern			
Bell shaped	31 (78)	30 (75)	1.000
Tower	1 (3)	1 (2.5)	
Staccato	6 (15)	6 (15)	
Interrupted	0	1 (2.5)	
Plateau	2 (5)	2 (5)	

[b]Fisher exact test was used, [c]independent t-test was used

Discussion

It has long been recognized that children with dysfunctional voiding (DV) and recurrent UTIs often have associated bowel dysfunction, including constipation and encoporesis.[10] Bladder and bowel dysfunctions describe a myriad of lower urinary symptoms, accompanied by bowel complaints, and represent up to 40% of pediatric urology consults.[11] Studies of children with functional bowel dysfunction had accompanying UTI in 10% of children.[12] Thirty-five percent of patients with BBD experienced recurrent UTI.[13] In this series, 48% of R-UTI patients had constipation compared to 15% of No-UTI patients who had constipation (p=0.002).

R-UTI group had a significantly higher frequency of daytime voided volume of > 125% of EBC, voided volume and maximum voided volume. The present data were in congruence with those in literature wherein there were significantly more patients with lower urinary tract malfunction having frequency of > 7 voids per day at 30.8% vs 13.6% (control).[14] Patients with voiding problems had a median voided volume of 150.5 mL (8-646 mL).[15]

Bladder wall thickness varies minimally with age but is influenced by bladder filling state. When the bladder was distended the upper limit of normal thickness was 3 mm and this rose to 5 mm when the bladder was emptied.[16,17] Mean bladder thickness was significantly higher in R-UTI patients compared to controls (3.83 ± 0.68mm vs 3.38 ± 0.62 mm, p=0.0030) in this series. This was comparable with the literature wherein 92% of patients who had a thick bladder pattern had detrusor overactivity on urodynamics.[18]

Observed bladder capacity (OBC) was significantly higher in the R-UTI group. This could be mainly due to the observation that the PVR and voided volume of the R-UTI group were significantly higher than the No-UTI group.

Residual urine in the bladder had been cited as a factor in the recurrence of urinary tract infection. Mean post-void residual urine in this series was significantly higher (12.96 ± 10.54 mL vs 5.21 ± 5.68 mL). Post-void residual urine was a risk factor for UTI recurrence with a positive correlation with the number of subsequent UTIs.[8] Elevated PVR and younger age were independent risk factors for recurrent UTI in children.[19]

Peak flow velocity in this series was comparable between the two groups. This was in congruence with those of Shaikh, et al. wherein peak flow velocity did not correlate with the number of subsequent UTIs. This could be because the results are influenced by the child's experience and comfort with the procedure and equipment. Further study is warranted.[8]

There were conflicting data with the relationship of EMG pattern in patients with UTI. Dyssynergia did not correlate with number of previous UTIs, volume of residual urine or subsequent UTIs.[8] However in the study by Kanitkar, dyssynergic voiding was found to be significantly more common in patients with recurrent UTI at 29.4% vs 2.9% of patients without recurrent UTI.[20]

Staccato uroflow pattern was considered representative of DV, but there had been reports that only a third of children with staccato flow had an active pelvic floor electromyography (EMG) during voiding.[21] In children with DV diagnosed by uroflow/EMG, staccato uroflow pattern was the most common pattern seen but nearly a third had interrupted or mixed flow pattern.[22,14] Uroflow pattern was abnormal in 67%-78% of patients with recurrent UTI[8] and 20% of normal patients[14] and this runs contrary to the present series in which bell-shaped pattern was the most common uroflow pattern in both groups. Despite the higher incidence of abnormal uroflow pattern in Shaikh's series, there was no correlation between abnormal uroflow pattern and number of subsequent UTIs.[8]

Conclusion

Constipation was more frequent in the R-UTI group. R-UTI group had a higher mean frequency of EBC > 125% during daytime, frequency, mean average voided volume, mean average voided volume during daytime, mean maximum voided volume, mean bladder thickness, mean PVR compared to the No-UTI group. Mean observed bladder capacity was observed to be greater than the EBC in the R-UTI group compared to the No-UTI group. R-UTI group was synergic compared to No-UTI group which were dyssynergic.

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